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(54) Title: FLEXIBLE POLISHING PAD HAVING REDUCED SURFACE STRESS

(57) Abstract: A polishing member for use in the chemical mechanical planarization of a semiconductor wafer has a first surface for contacting the semiconductor wafer, a second surface opposite the first surface oriented away from the wafer. A plurality of grooves formed in the second surface. The plurality of grooves enable the polishing member to conform to the surface of the wafer and provide uniform polishing of the wafer. In one embodiment the polishing member comprises a linear belt having at least two portions mated at a joint. The plurality of grooves reduce the stress on the joints by increasing the flexibility of the belt thereby reducing the risk of delamination of the belt and joints.

FLEXIBLE POLISHING PAD HAVING REDUCED SURFACE STRESS

FIELD OF THE INVENTION

The present invention relates to a polishing member for use in chemical mechanical planarization applications. More particularly, the present invention relates to a flexible pad used in the chemical mechanical planarization or polishing of semiconductor wafers.

BACKGROUND

Semiconductor wafers are typically fabricated with multiple copies of a desired integrated circuit design that will later be separated and made into individual integrated circuit chips. A common technique for forming the circuitry on a semiconductor is photolithography. Part of the photolithography process requires that a special camera focus on the wafer to project an image of the circuit on the wafer. The ability of the camera to focus on the surface of the wafer is often adversely affected by inconsistencies or unevenness in the wafer surface. The need for a precise image projection is accentuated with the current drive toward smaller, more complex integrated circuit designs. Semiconductor wafers are also commonly constructed in layers, where a portion of a circuit is etched on a first level and conductive vias are made to connect up to the next level of the circuit. After each layer of the circuit is etched on the wafer, an oxide layer is put down that allows the vias to pass through the oxide layer while covering the rest of the previous circuit level. Each layer of the circuit can create or add unevenness to the wafer as it is constructed. These imperfections are preferably smoothed out before generating the next circuit layer.

Chemical mechanical planarization (CMP) techniques are used to planarize the raw wafer and each layer of material added thereafter. Available CMP systems, commonly called wafer polishers, often use a rotating wafer holder that brings the wafer into contact with a polishing pad that is moving in the plane of the wafer surface to be planarized. A polishing fluid, such as a chemical polishing agent or slurry containing microabrasives, is applied to the polishing pad to polish the wafer. The wafer holder then presses the wafer against the rotating polishing pad and is rotated to polish and planarize the wafer.

The polishing pads commonly used in this process include both belt-type pads and rotary-type pads. A belt-type pad typically consists of one or more sections of material that are joined together through lamination or the like to form a belt. The belt is placed around a plurality of rollers that cause the belt to rotate. However, as the belt rotates around the rollers, the belt is subjected to stress as it bends around the rollers. This stress is especially high on the outer surface of the belt and can cause joints to fail as a result of delamination or otherwise. In addition, the belt-type pads do not easily conform to the surface of the wafer and can produce uneven polishing of the wafer.

A rotary-type pad typically consists of one or more sections of material that are joined together to form a pad. The pad is attached to a rotary machine that rotates the pad to polish a wafer. However, the pad does not easily conform to the surface of the wafer and can produce uneven polishing of the wafer. Accordingly, polishing pad that overcomes these deficiencies is needed.

SUMMARY OF THE INVENTION

According to one aspect of the invention, a polishing member has a first surface for contacting a wafer and a second surface opposite the first surface. The second surface includes one or more grooves formed in the surface. The grooves enable the pad to conform to the surface of the wafer to produce increased uniformity in the polishing.

According to another aspect of the invention, a polishing member comprises one or more sections of material that are formed in a belt that is movable in a linear path. The belt has a first surface for contacting a wafer and a second surface opposite the first surface. A plurality of grooves are formed in the second surface preferably perpendicular to the linear path of the belt. The grooves enable the pad to conform to the surface of the wafer to produce increased uniformity in the polishing and also allow the belt to linearly compress thereby reducing the stress on the first surface of the belt.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a polishing member of a first preferred embodiment.

FIG. 2 is side view of a portion of the polishing member of FIG. 1.

FIG. 3 is a side view of a polishing member of a second preferred embodiment.

FIG. 4 is a side view of a portion of the polishing member of FIG. 2.

FIG. 5 is a perspective view of the polishing member of FIG. 1

FIG. 6 is a side view of a polishing member of a third preferred embodiment.

FIG. 7 is a side view of a portion of a polishing member of a fourth preferred embodiment.

FIG. 8 is a side view of a portion of a polishing member of a fifth preferred embodiment.

FIG. 9 is a side view of a portion of a polishing member of a sixth preferred embodiment.

FIG. 10 is a side view of a portion of a polishing member of a seventh preferred embodiment.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

By way of introduction, the preferred embodiments described below include a polishing member having a first surface for contacting a wafer and a second surface opposite the first surface. The second surface includes one or more grooves formed in the surface. In one embodiment, the polishing member comprises one or more polishing pad sections that are linked to form a belt that is to be used with rollers. The first surface is exposed for contacting and polishing a wafer while the second surface is oriented towards the rollers and does not contact the wafer. A plurality of grooves are formed in the second surface that increase the flexibility of the belt and allow the second surface of the belt to linearly compress when the belt bends. Thus, the belt is able wrap around the rollers more easily and less stress is placed on the first surface. This reduces the overall stress on the belt as it rotates around the rollers and reduces the stress on the joints as well.

In another embodiment, the polishing member comprises a polishing pad for use in rotary-type polisher. The polishing pad has a first surface for contacting a wafer and a second surface opposite the first surface. The second surface is oriented toward the polisher and does

not contact the wafer. One or more grooves are formed in the second surface. These grooves increase the flexibility of the pad and enable the pad to conform to the surface of the wafer and allow for more uniform polishing of the wafer.

By way of example, FIG. 1 depicts a polishing member 10 of a preferred embodiment. The polishing member comprises a single piece of polishing material 20 that has first and second ends 22, 24. The first and second ends 22, 24 are joined at a joint 26 to form a polishing belt. The first and second ends are typically joined through lamination or other such processes as known to those skilled in the art. The polishing belt has a first surface 28 and a second surface 30. The first surface 28 is preferably oriented such that it can contact a wafer to polish the wafer. The second surface 30 is opposite the first surface 28 and is oriented away from the wafer.

The polishing belt is preferably used in conjunction with a plurality of rollers 40, 42 that can be rotated. The second surface 30 contacts the rollers 40, 42 and allows the rollers to cause the belt to be rotated. A plurality of grooves 32 are formed in the second surface 30. The grooves 32 enable the second surface 30 to flex and linearly compress as the polishing belt rotates around the rollers 40, 42. This reduces the stress placed on the first surface 28 and the joint 26, especially when the joint 26 passes around the rollers 40, 42. The likelihood of delamination of the joint 26 is thereby reduced.

As shown in FIG. 2, the grooves 32 are preferably formed with a nearly triangular cross section. The grooves 32 are preferably formed to a depth d_1 and the sides of the grooves 34, 36 are preferably formed to create an angle 2 there between. The depth d_1 can be virtually any depth less than the thickness of the polishing belt. The angle 2 is preferably between 10 and 45 degrees but can be virtually any angle. The grooves 32 are preferably laterally spaced along the second surface 30 of the polishing belt, but can be positioned directly adjacent to one another without any spaces between the grooves 32. A steel belt can also be used in conjunction with the polishing belt. The polishing belt can be coupled with the steel belt, which can serve as a supporting structure. The steel belt can contact the rollers to enable the polishing belt to be rotated.

Referring now to FIG. 3, in an alternative embodiment, the polishing member 110 can comprise a polishing belt including single piece of material 120 having first and second ends

122, 124, a joint 126, a first surface 128, a second surface 130, a plurality of grooves 132, and a plurality of rollers 140, 142 as described above. In this embodiment, a substrate 150 is coupled with the polishing belt and is placed between the polishing belt and the rollers 140, 142. The phrase "coupled with," as used herein, means coupled either directly or indirectly via one or more intervening elements. The substrate 150 preferably comprises cushioning material such as polyurethane felt. The substrate 150 can preferably be expanded or compressed in a linear directions such that the second surface 130 of the polishing belt can be compressed as the polishing belt rotates around the rollers 140, 142. The substrate 150 can also comprise one or more materials that can serve as an intermediate layer between the polishing belt and the rollers or a steel belt. A steel belt can also be coupled with the substrate 150 and can be placed between the substrate 150 and the rollers 140, 142. An adhesive can be used to join the substrate 150 and the polishing belt. However, other suitable methods of joining the substrate 150 and the polishing belt can be used.

As shown in FIG. 4, the grooves 132 are preferably formed with a nearly triangular cross section. The grooves 132 are preferably formed to a depth d_2 that is preferably equal to the combined thickness t_1 of the substrate 150 and any adhesive used therewith. Alternatively, the depth d_2 can be equal to a portion of the combined thickness t_1 of the substrate 150 and any adhesive used therewith, or the depth d_2 can be selected irrespective of the thickness t_1 of the substrate 150. The sides of the grooves 134, 136 are preferably formed to create an angle 2 there between. The angle 2 is preferably between 10 and 45 degrees but can be any angle.

The polishing members 10, 110 are preferably movable in a linear plane 160 as shown in FIG. 5. The grooves 32, 132 are preferably formed substantially perpendicular to the linear plane 160. This provides for the most efficient surface stress reduction on the belt and on the joints 26, 126; especially when the polishing belt rotates around the rollers 40, 42, 140, 142. Alternatively, the grooves 32, 132 can be oriented at any angle with respect to the linear plane 160.

While the polishing members 10, 110 of FIGS. 1-5 are depicted as being constructed from a single piece of material, the polishing members 10, 110 can be constructed from multiple polishing pad pieces as known to those skilled in the art. The multiple polishing pad pieces can be joined through the use of any type of joint known to those skilled in the art including

lamination. A resulting belt will contain multiple joints thereby increasing the possible points of delamination described above. In this orientation the reduction in stress and possible delamination resulting from the presence of the grooves 32, 132 is further increased.

Referring now to FIG. 6, in an alternative embodiment, the polishing member 210 can comprise one or more pieces of material forming a polishing pad 220. A substrate 250 can be used in conjunction with the polishing pad 220 but is not required. The polishing pad has a first surface 228 and a second surface 230. The first surface 228 is preferably oriented such that it can contact a wafer for polishing. The second surface 230 is opposite the first surface 228 and is preferably coupled with a rotary table 240. A plurality of grooves 232 are formed in the second surface 230. The grooves 232 increase the flexibility of the polishing pad 220 thereby enabling the polishing pad 220 to conform to the surface of the wafer to increase the uniformity of the polishing. The polishing pad 220 is preferably used in conjunction with a rotary polisher that rotates the pad to polish a wafer. The substrate 250 can comprise any of the substrates 150 discussed above.

As shown in FIG. 6, the grooves 232 are preferably formed with a nearly triangular cross section. The grooves 232 are preferably formed to a depth d_3 that is preferably equal to the thickness t_2 of the substrate 250 and any adhesive used therewith. Alternatively, the depth d_3 can be equal to a portion of the thickness t_2 of the substrate 250 and any adhesive used therewith, or the depth d_3 can be selected irrespective of the thickness t_2 of the substrate 250. The sides of the grooves 234, 236 are preferably formed to create an angle 2 there between. The angle 2 is preferably between 10 and 45 degrees but can be any angle.

As depicted in the alternative embodiments of FIGS. 7-10, the grooves 32, 132, 232 can be formed with any suitable cross sectional shape. For example, the grooves 32, 132, 232 can be formed with a trapezoidal cross sectional shape as shown in FIG. 7, a triangular cross sectional shape as shown in FIG. 8, a semi-circular or circular cross sectional shape as shown in FIG. 9, or a square cross sectional shape as shown in FIG. 10. Other suitable cross section shapes that allow the polishing member to flex and compress can be used. While the grooves 32, 132, 232 preferably have a uniform cross sectional shape, the grooves 32, 132, 232 can have varying cross sectional shapes.

The polishing member includes a plurality of grooves that enable the polishing member to conform to the surface of the wafer and provides for uniform polishing of the wafer. The grooves in the polishing member also reduce the stress on the outer surface of the member when it rotates and bends around the rollers. By reducing the stress on the polishing member, the life of the polishing member can be increased and the uniformity of the polishing is increased.

It is to be understood that a wide range of changes and modifications to the embodiments described above will be apparent to those skilled in the art and are contemplated. It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, that are intended to define the spirit and scope of the invention.

I claim:

1. A polishing member belt for use in chemical mechanical planarization of a semiconductor wafer, the polishing member comprising:

a first surface for contacting the semiconductor wafer;

a second surface opposite the first surface; and

a plurality of grooves formed in the second surface.

2. The invention of claim 1, wherein the plurality of grooves have a triangular cross section.

3. The invention of claim 1, wherein the plurality of grooves have a trapezoidal cross section.

4. The invention of claim 1, wherein the plurality of grooves have a rectangular cross section.

5. The invention of claim 1, wherein the polishing member comprises a belt that is movable in a linear path and the plurality of grooves are substantially perpendicular to the linear path.

6. The invention of claim 1, further comprising a substrate coupled with the second surface.

7. The invention of claim 1, further comprising a steel belt coupled with the second surface.

8. A polishing member for use in chemical mechanical planarization of a semiconductor wafer, the polishing member comprising:

a linear belt having a first surface for contacting the semiconductor wafer and a second surface opposite the first surface; and

a plurality of grooves formed in the second surface.

9. The invention of claim 8, wherein the polishing member is movable in a linear path and the plurality of grooves are oriented perpendicular to the linear path.

10. The invention of claim 8, wherein the plurality of grooves have a triangular cross section.

11. The invention of claim 8, wherein the plurality of grooves have a trapezoidal cross section.

12. The invention of claim 8, wherein the plurality of grooves have a rectangular cross section.

13. The invention of claim 8, further comprising a substrate coupled with the second surface.

14. The invention of claim 8, further comprising a steel belt coupled with the second surface.

15. A polishing member for use in chemical mechanical planarization of a semiconductor wafer, the polishing member comprising:

a plurality of serially linked polishing pad sections forming a linear belt;

a first surface for contacting the semiconductor wafer;

a second surface opposite the first surface; and

a plurality of grooves formed in the second surface.

16. The invention of claim 15, wherein the polishing member is movable in a linear path and the plurality of grooves are oriented perpendicular to the linear path.

17. The invention of claim 15, wherein the plurality of grooves have a triangular cross section.

18. The invention of claim 15, wherein the plurality of grooves have a trapezoidal cross section.

19. The invention of claim 15, wherein the plurality of grooves have a rectangular cross section.

20. The invention of claim 15, further comprising a substrate coupled with the second surface.

21. The invention of claim 15, further comprising a steel belt coupled with the second surface.

FIG 1

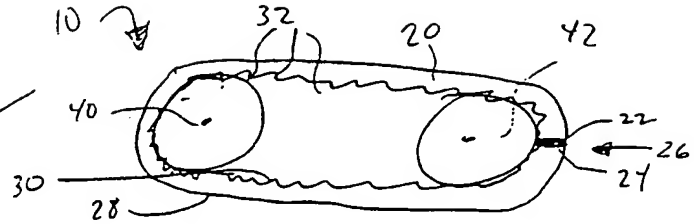

FIG 2

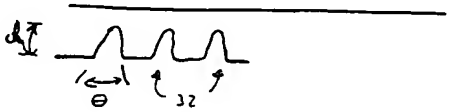

FIG 7

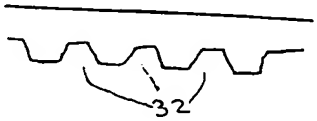

FIG 8

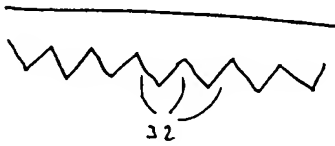

FIG 9

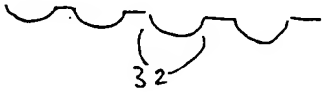

FIG 10

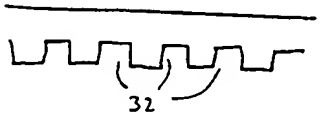

FIG 5

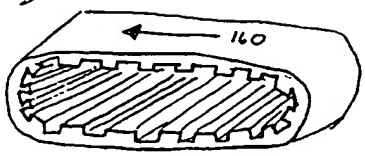

FIG 6

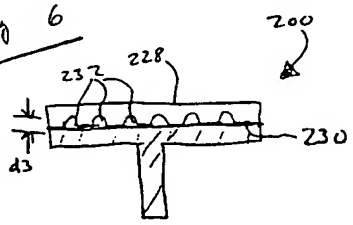

FIG 3

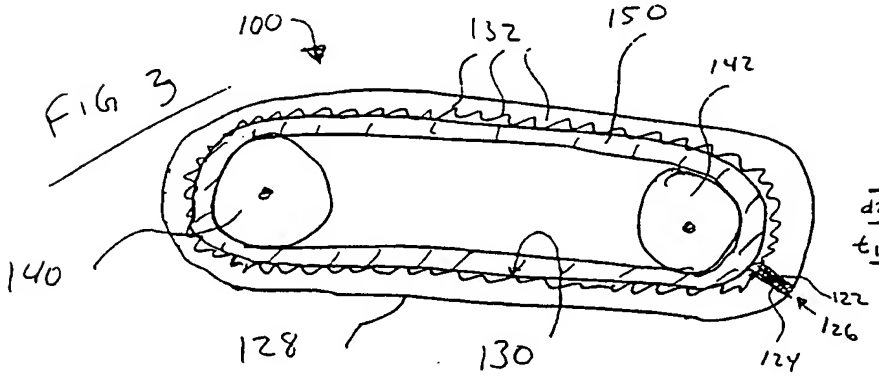

FIG 4